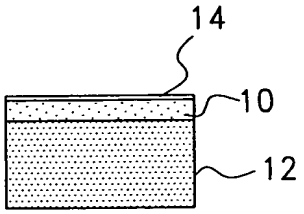


FIG.1(a)
(prior art)

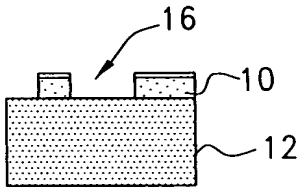


FIG.1(b)
(prior art)

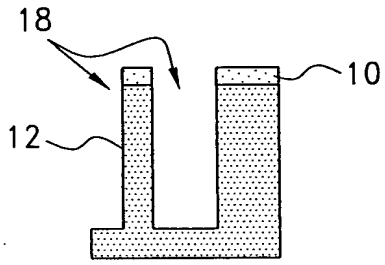


FIG.1(c)
(prior art)

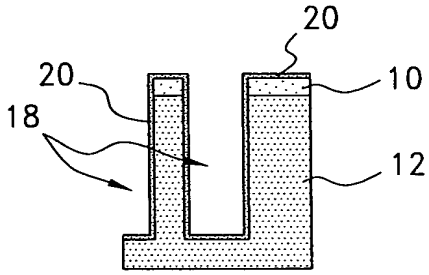


FIG.1(d)
(prior art)

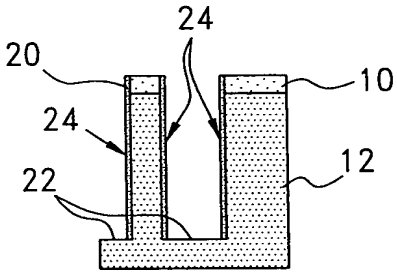


FIG.1(e)
(prior art)

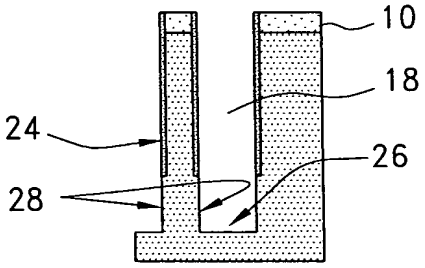


FIG.1(f)
(prior art)

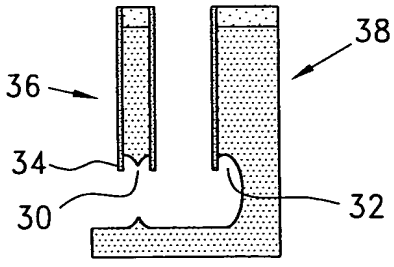


FIG.1(g)
(prior art)

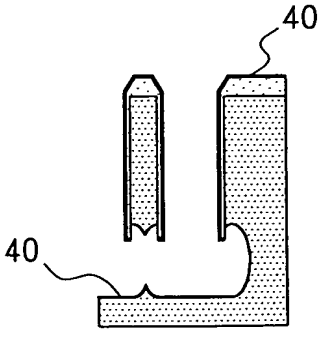


FIG.1(h)
(prior art)

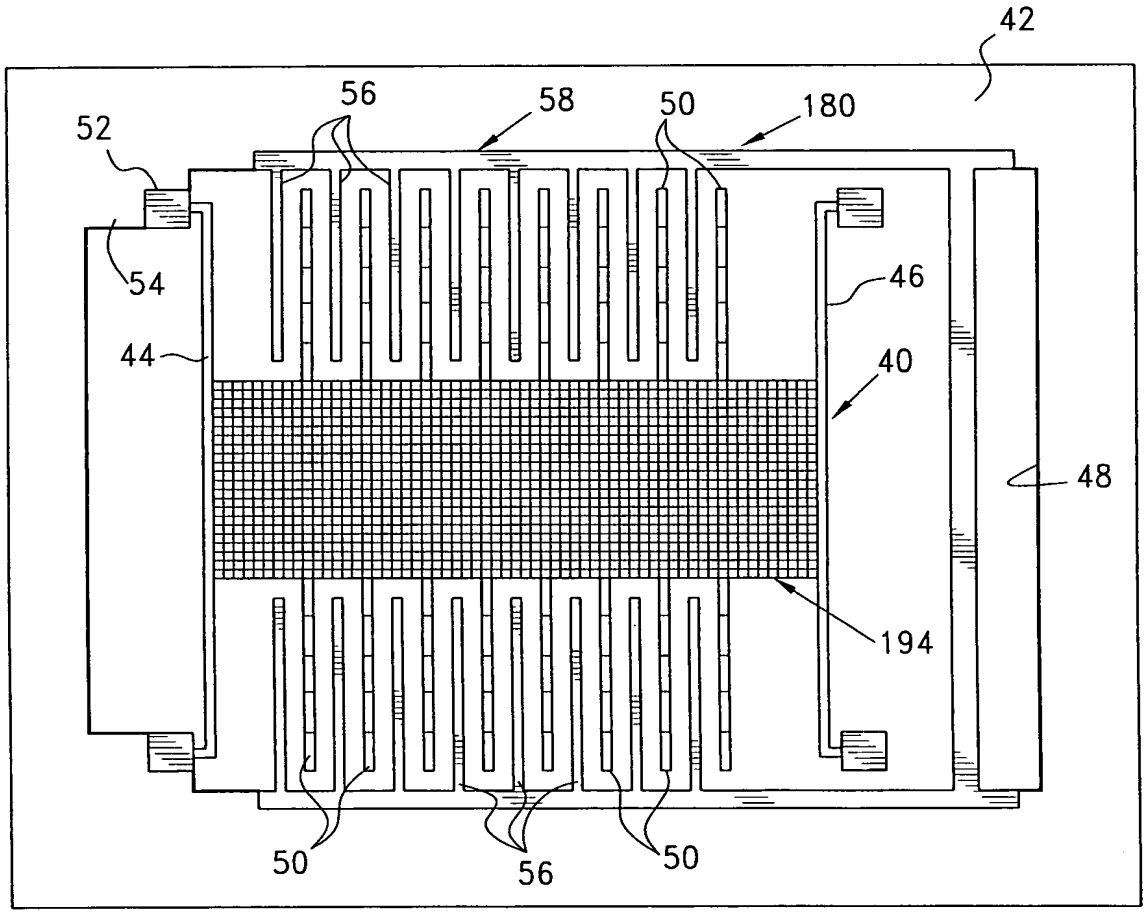


FIG.2
(prior art)

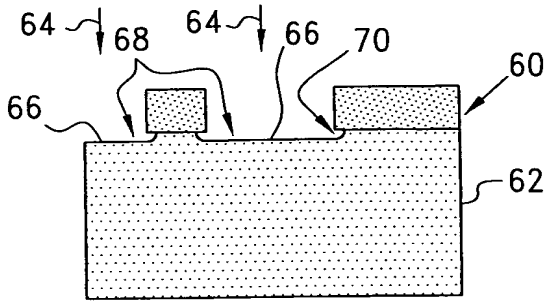


FIG.3(a)

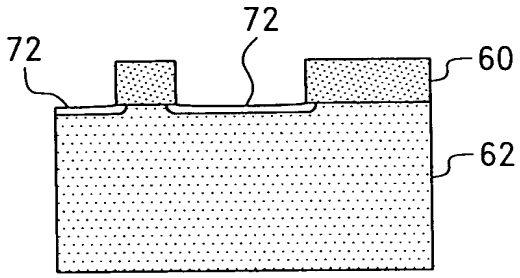


FIG.3(b)

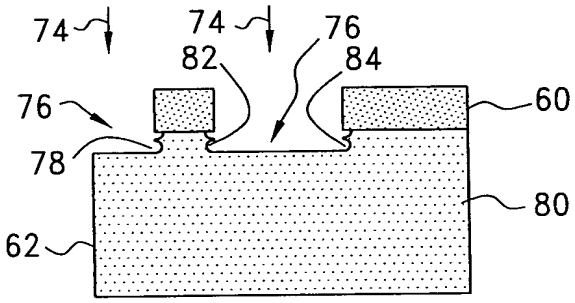


FIG.3(c)

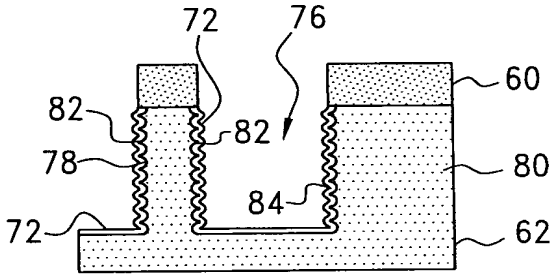


FIG.3(d)

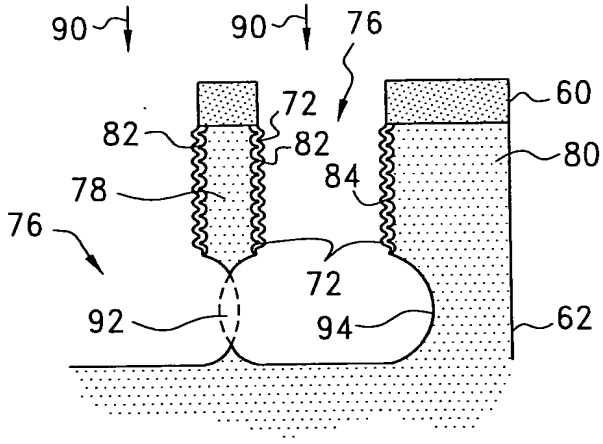


FIG.3(e)

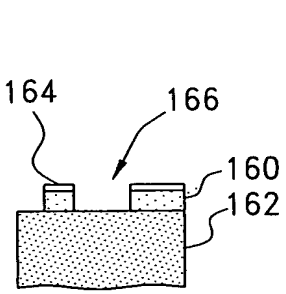


FIG.4(a)

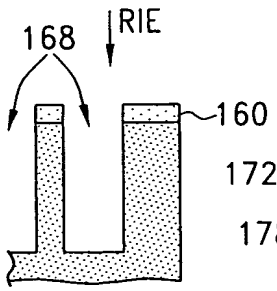


FIG.4(b)

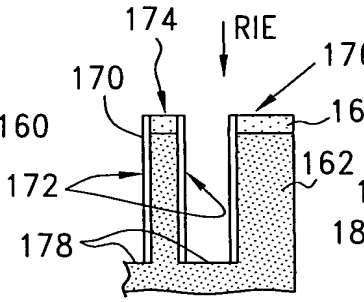


FIG.4(c)

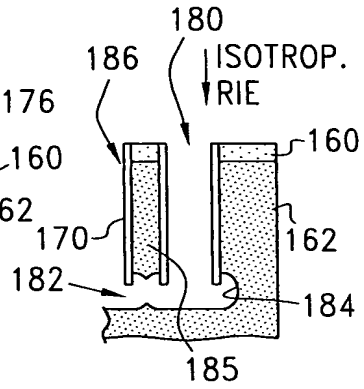


FIG.4(d)

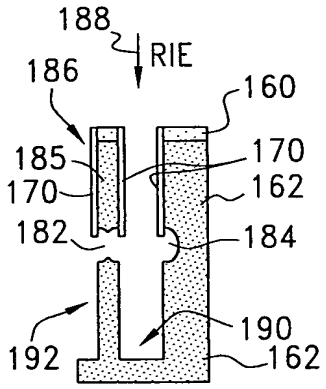


FIG.4(e)

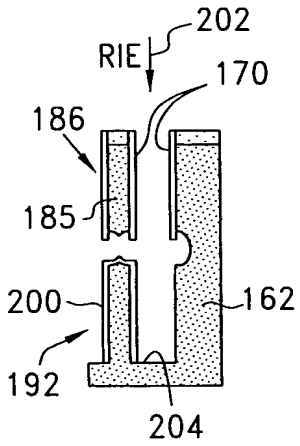


FIG.4(f)

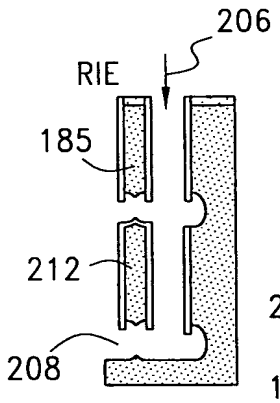


FIG.4(g)

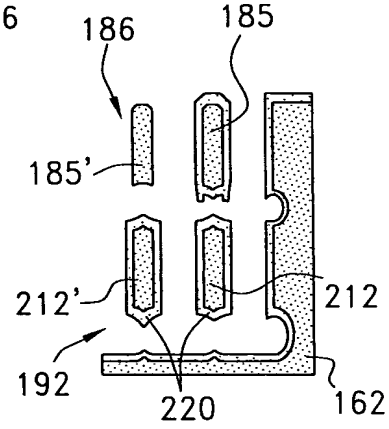


FIG.4(h)

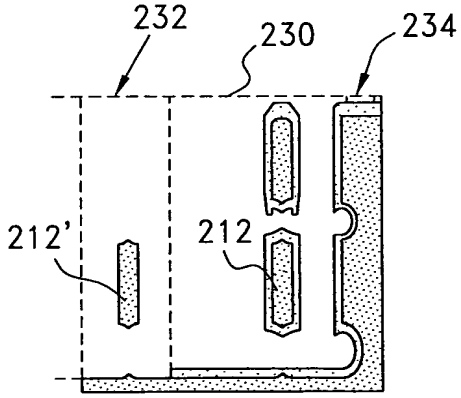


FIG.4(i)

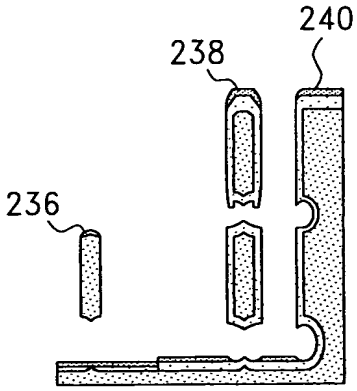


FIG.4(j)

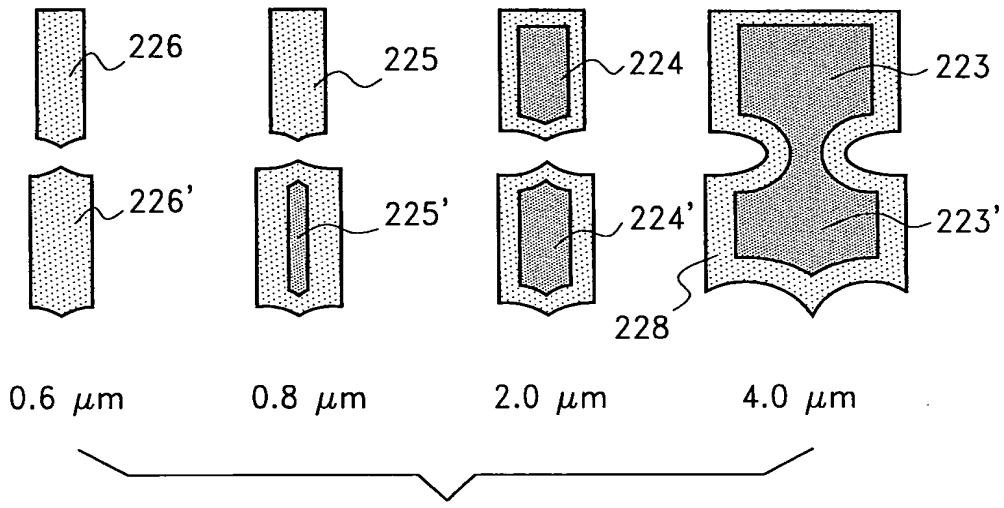


FIG.5

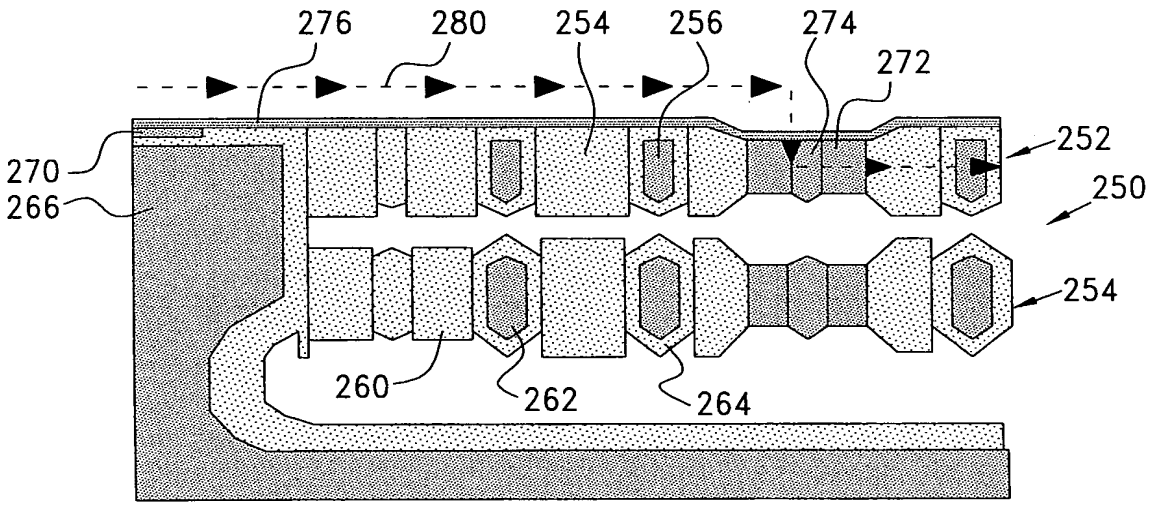


FIG.6(a)

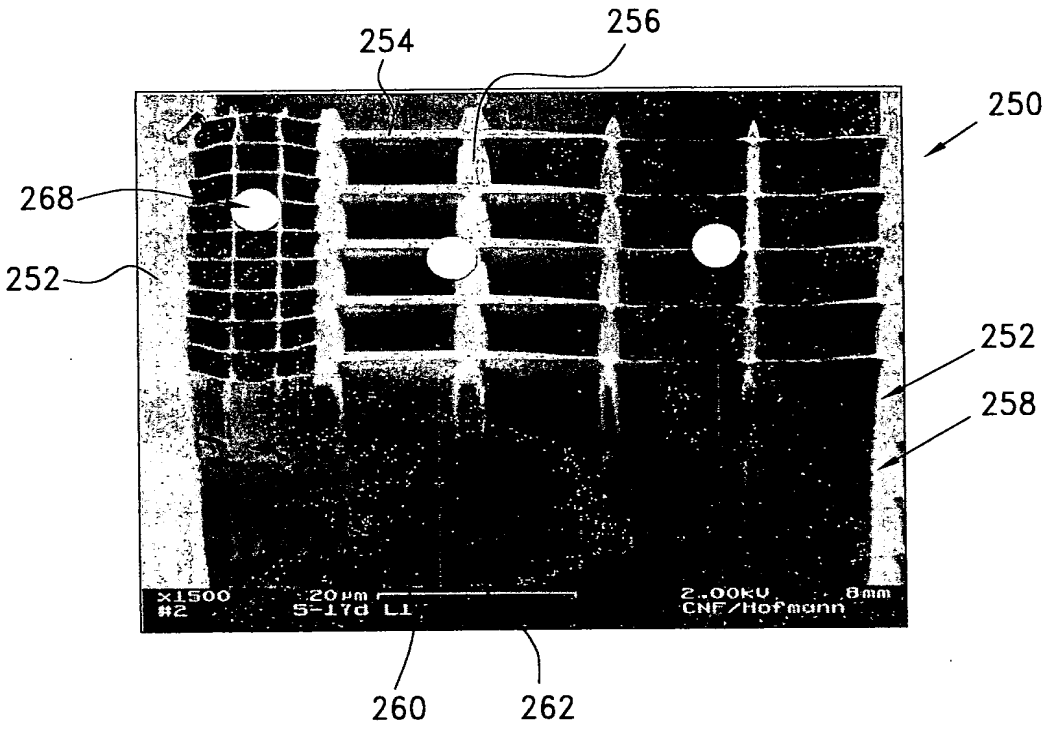

254
256
250
268
252
252
258
×1500 20µm 2.00kV 8mm
#2 5-17d L1 CNF/Hofmann
260
262

FIG.6(b)

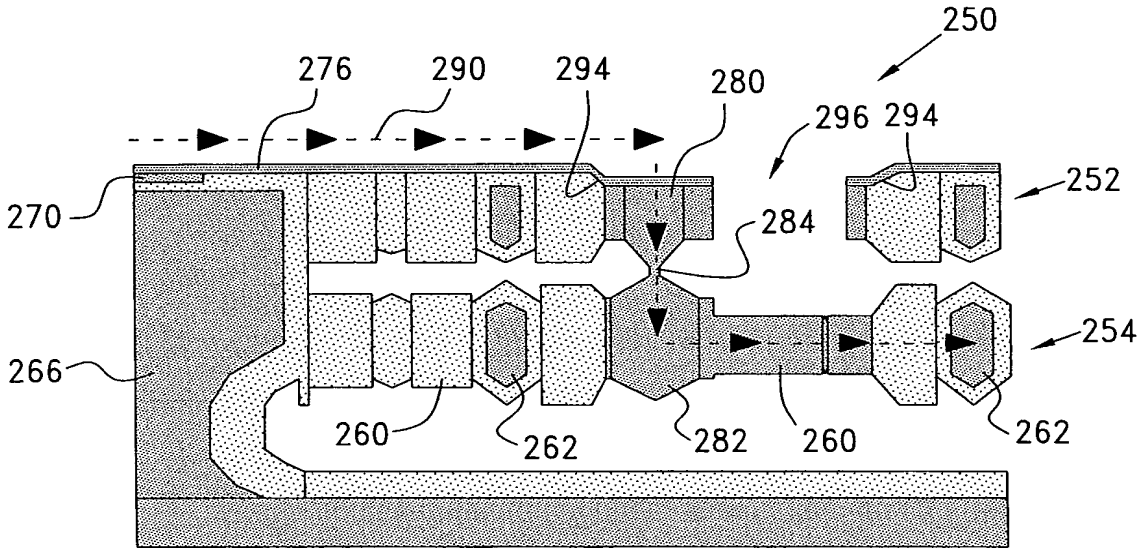

250
276
290
294
280
296
294
252
270
284
254
266
260
262
282
260
262

FIG.7(a)

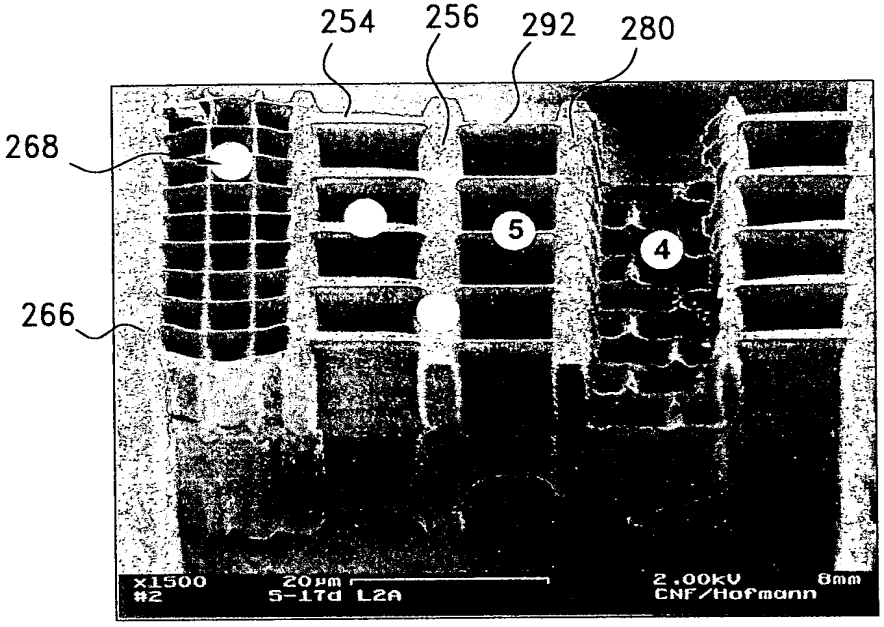

254
256
292
280
268
266
5
4
x1500
#2
20µm
5-1Td L2A
2.00kV
8mm
CNF/Hofmann

FIG.7(b)

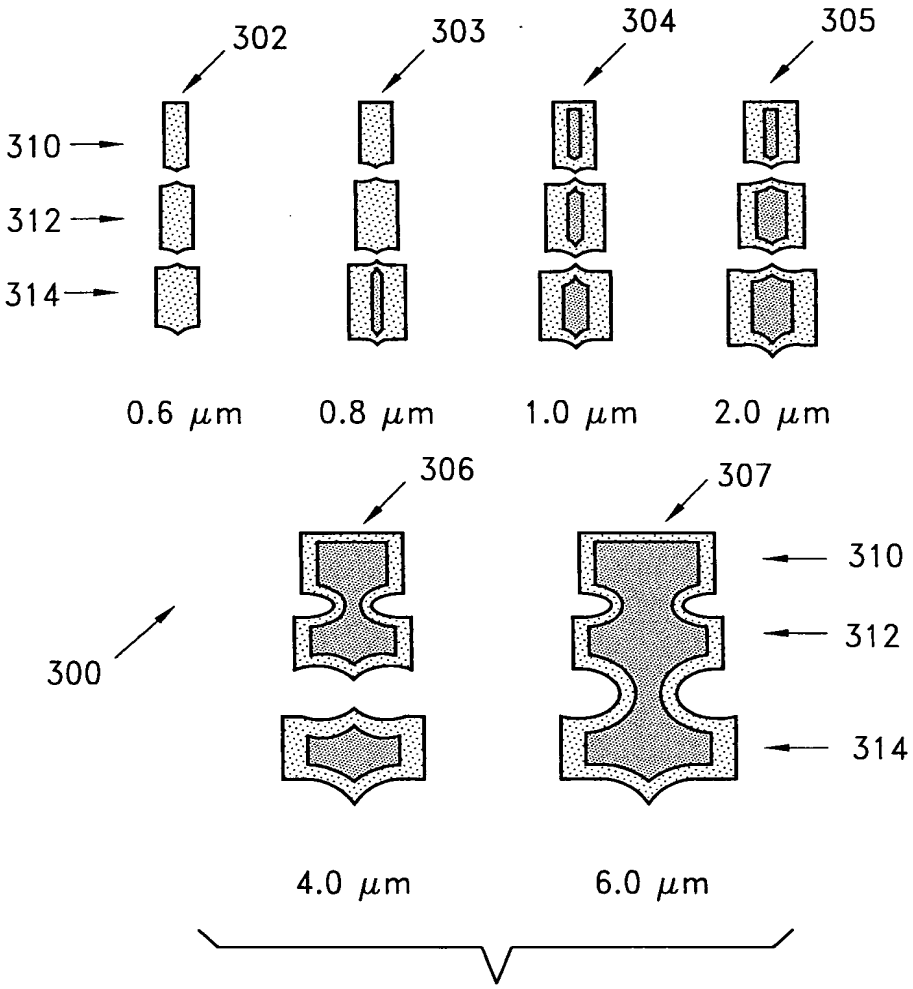

302
303
304
305
310
312
314
0.6 μm
0.8 μm
1.0 μm
2.0 μm
306
307
300
310
312
314
4.0 μm
6.0 μm

FIG.8

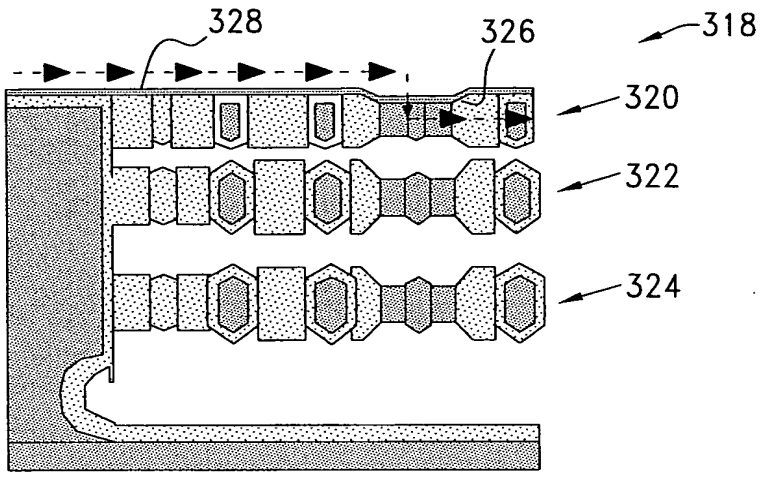


FIG.9(a)

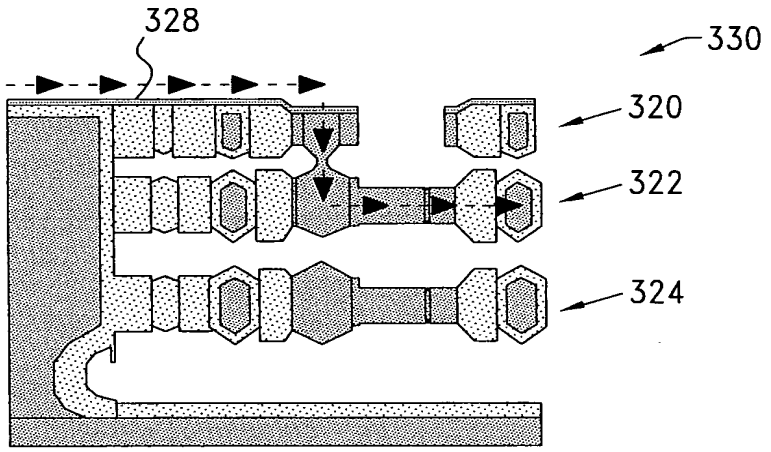


FIG.9(b)

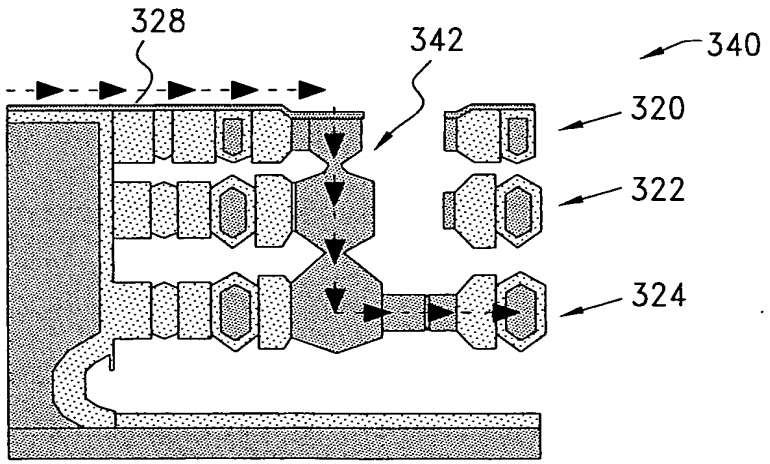


FIG.9(c)

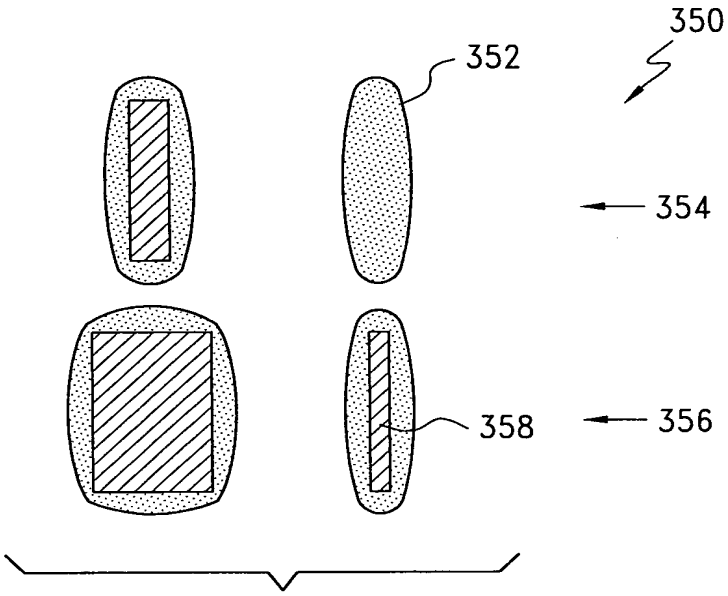


FIG.10

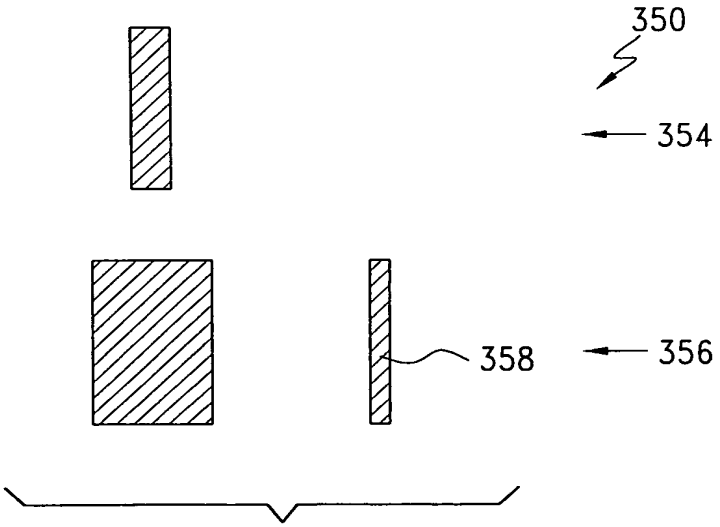


FIG.11

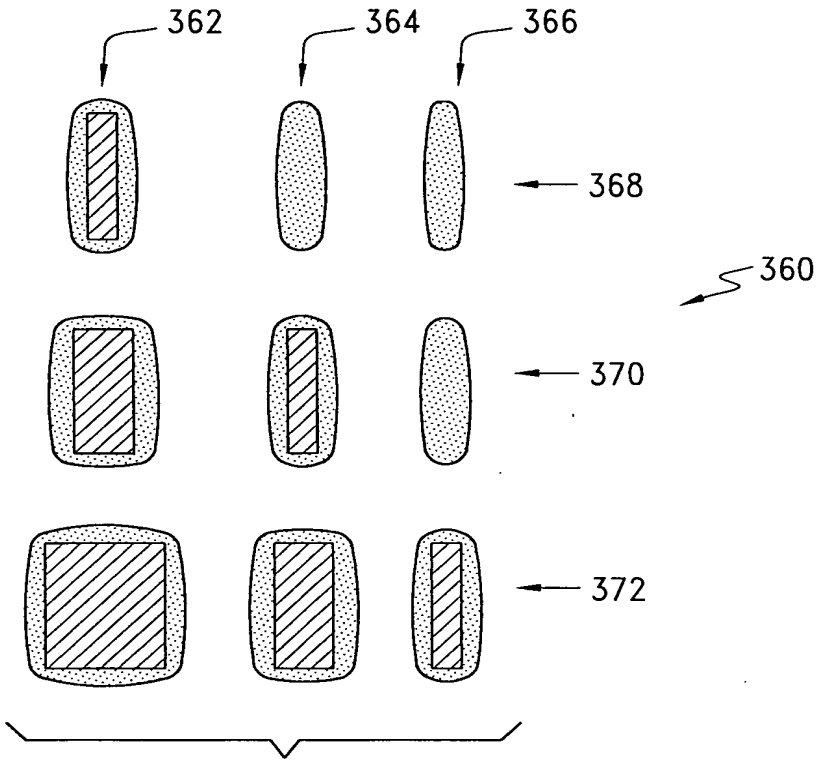


FIG.12

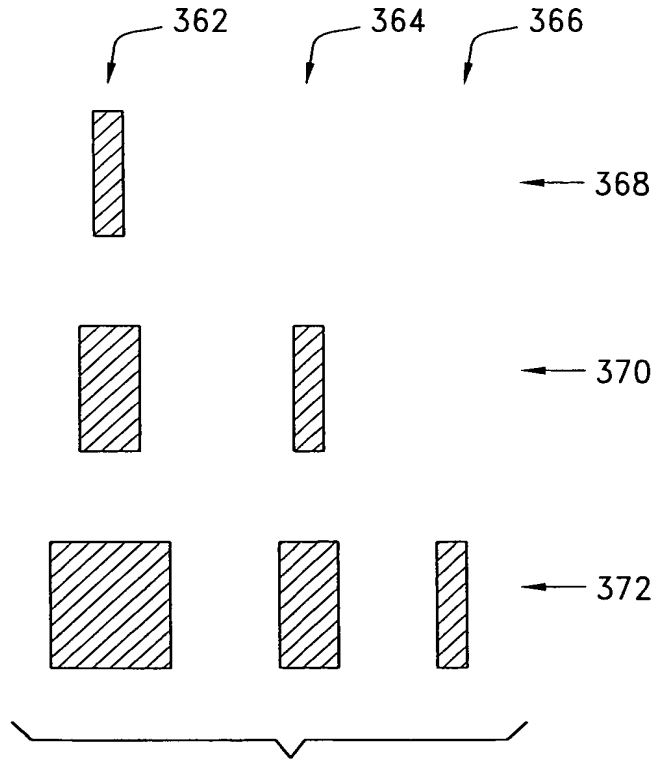


FIG.13

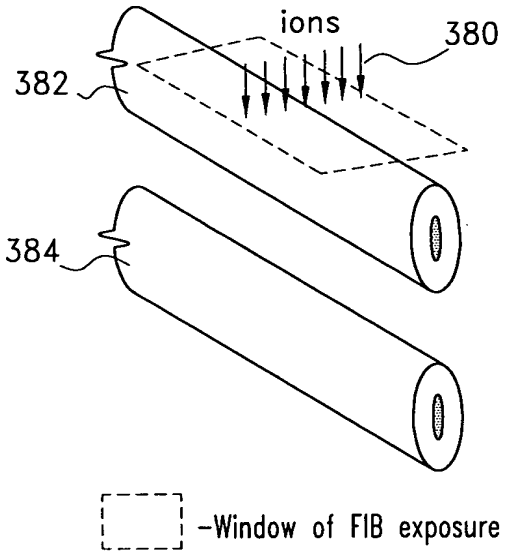


FIG.14(a)
-Upper Level
before

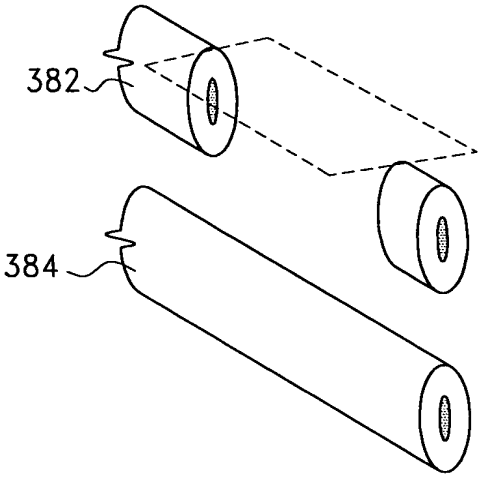


FIG.14(b)
-Upper Level
after

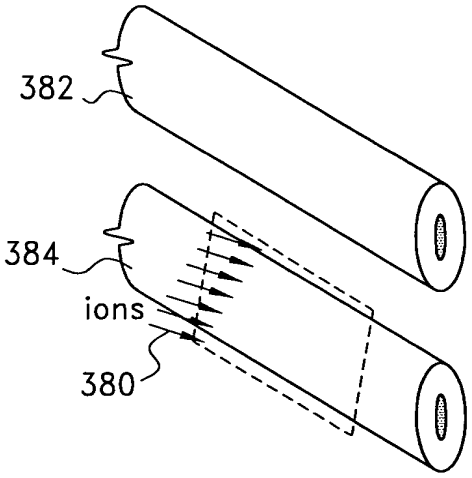


FIG.15(a)
-Lower Level

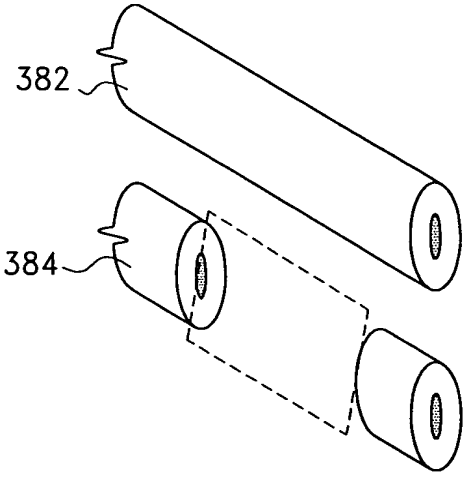


FIG.15(b)
-Lower Level

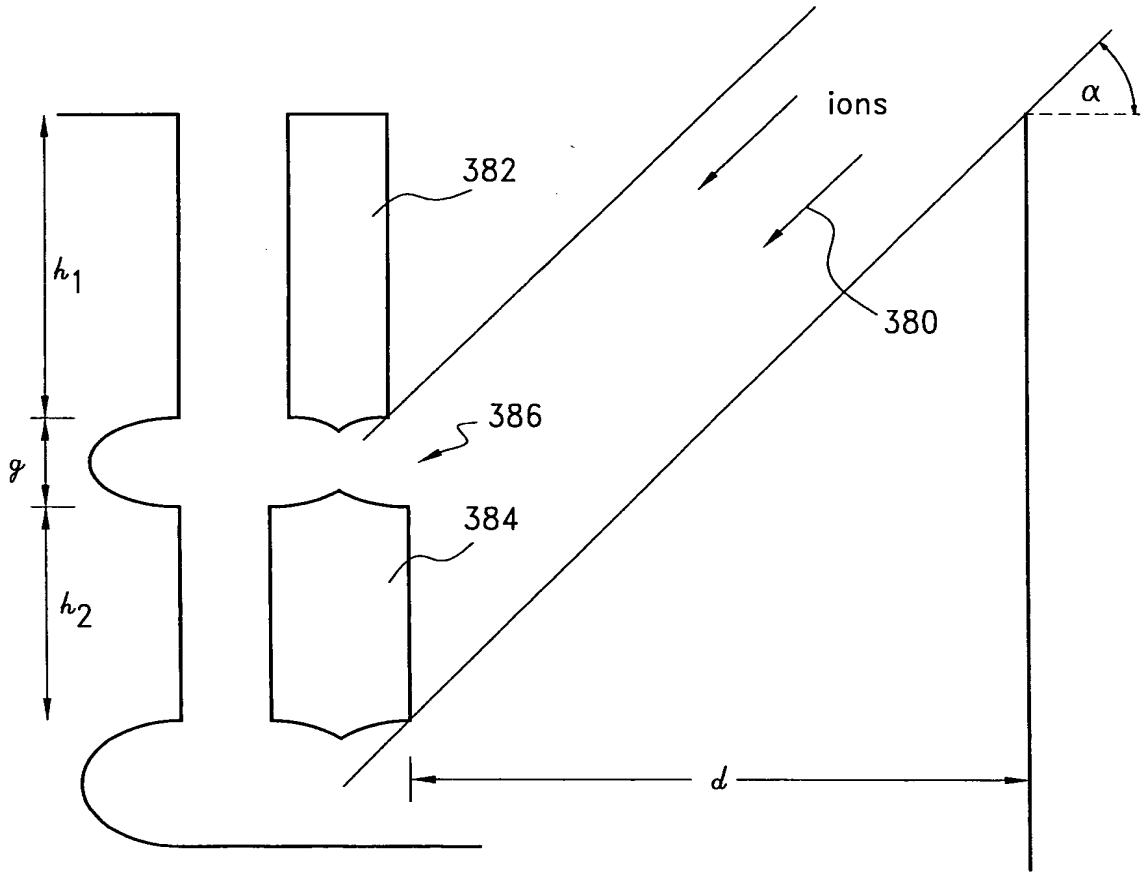


FIG.16

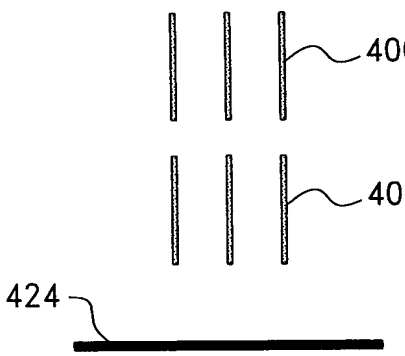


FIG.17(a)

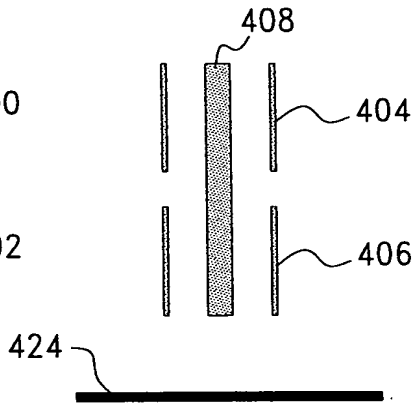


FIG.17(b)

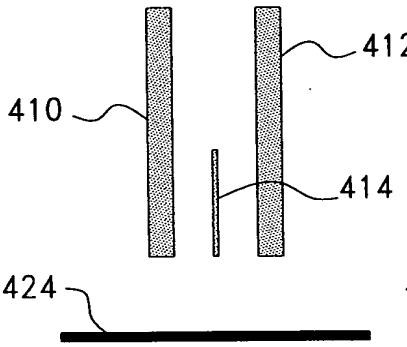


FIG.17(c)

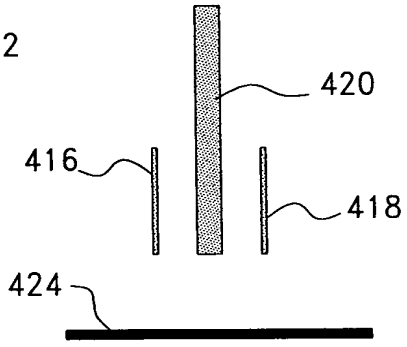


FIG.17(d)

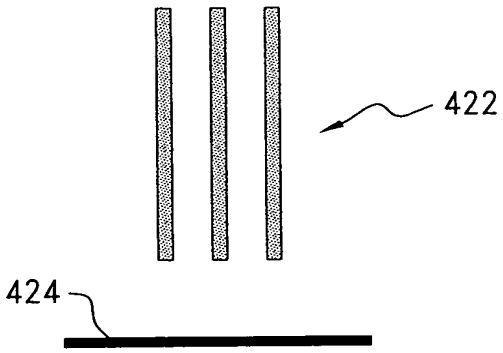


FIG.17(e)

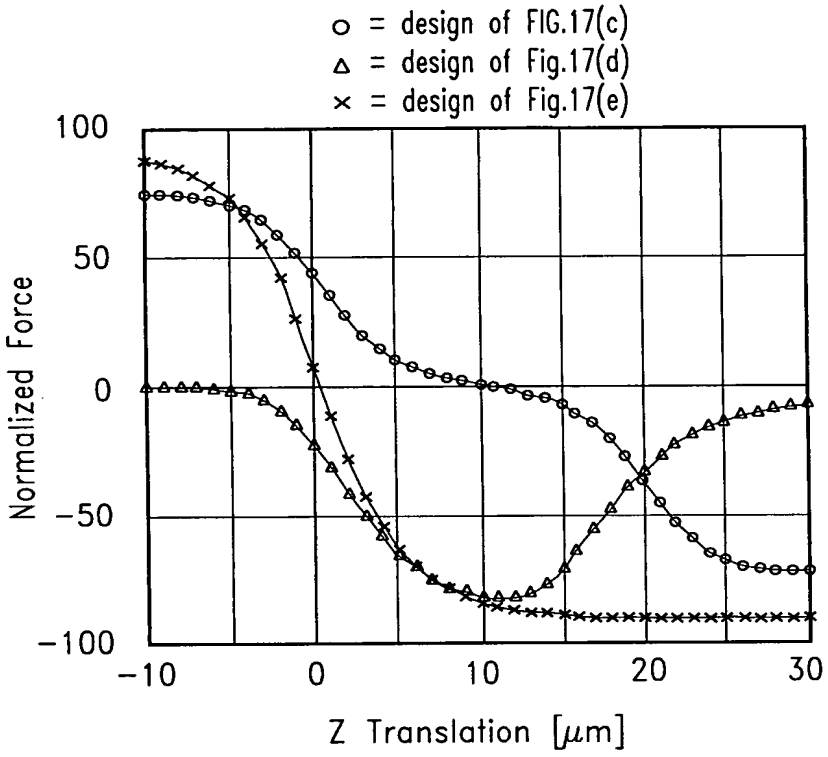

o = design of FIG.17(c)
Δ = design of Fig.17(d)
× = design of Fig.17(e)
100
50
0
−50
−100
Normalized Force
−10
0
10
20
30
Z Translation [μm]

FIG.18

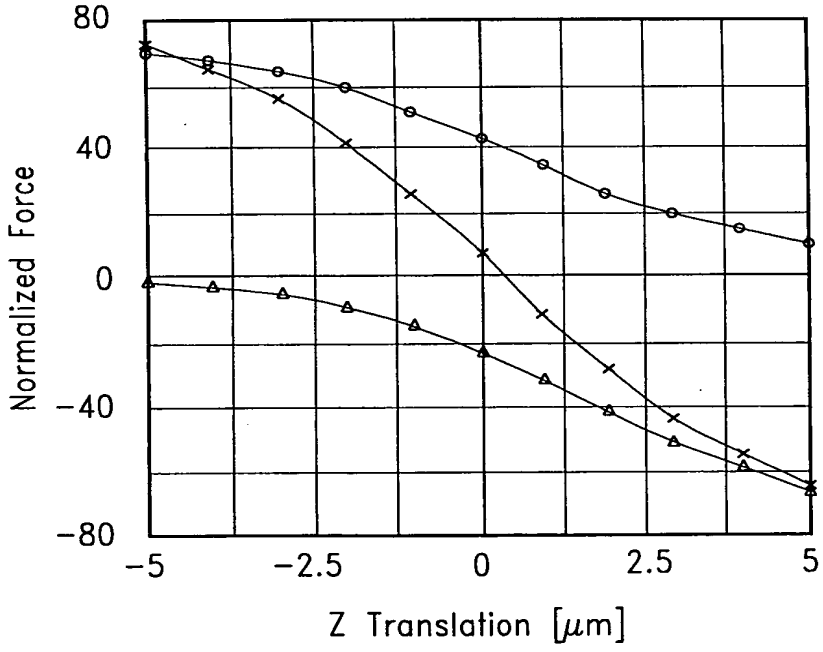

80
40
0
−40
−80
Normalized Force
−5
−2.5
0
2.5
5
Z Translation [μm]

FIG.19

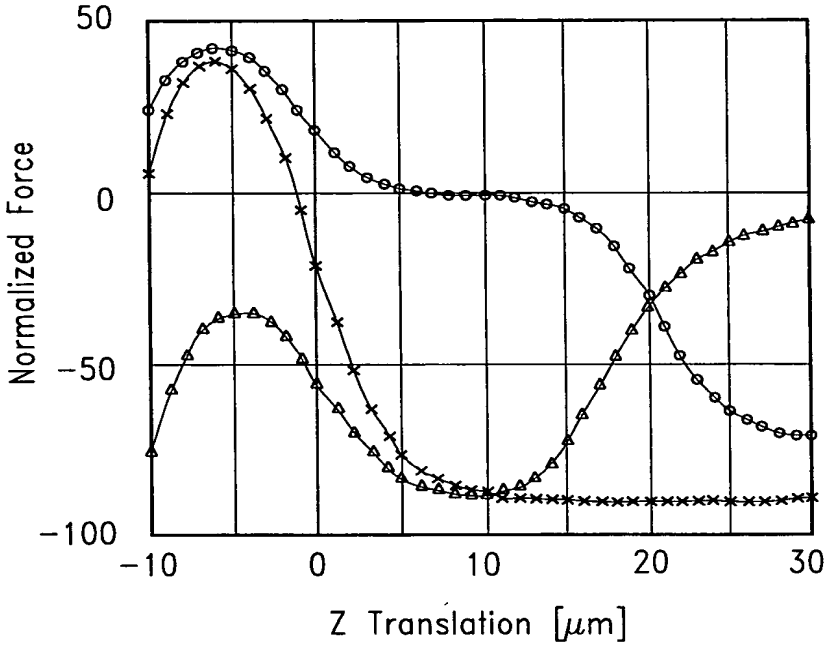

50
0
-50
-100
Normalized Force
-10
0
10
20
30
Z Translation [μm]

FIG.20

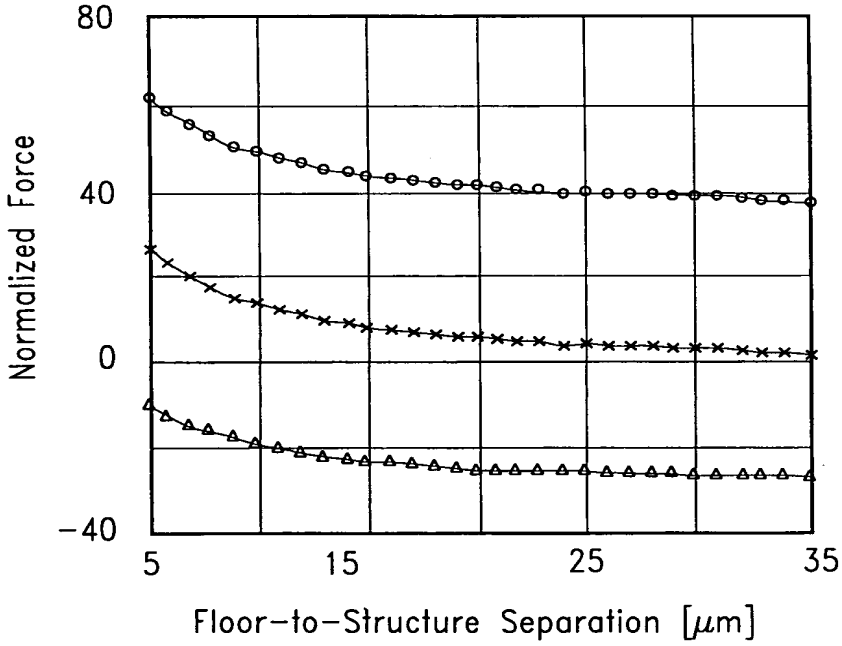

80
40
0
-40
Normalized Force
5
15
25
35
Floor-to-Structure Separation [μm]

FIG.21

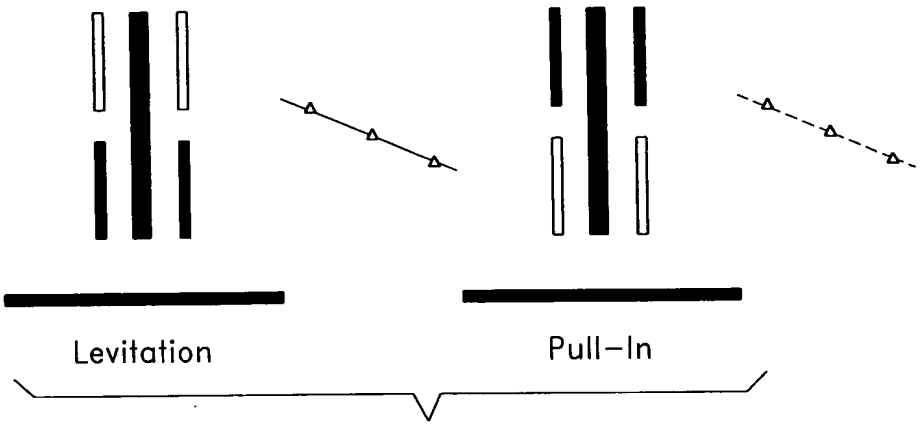

Levitation
Pull-In

FIG.22

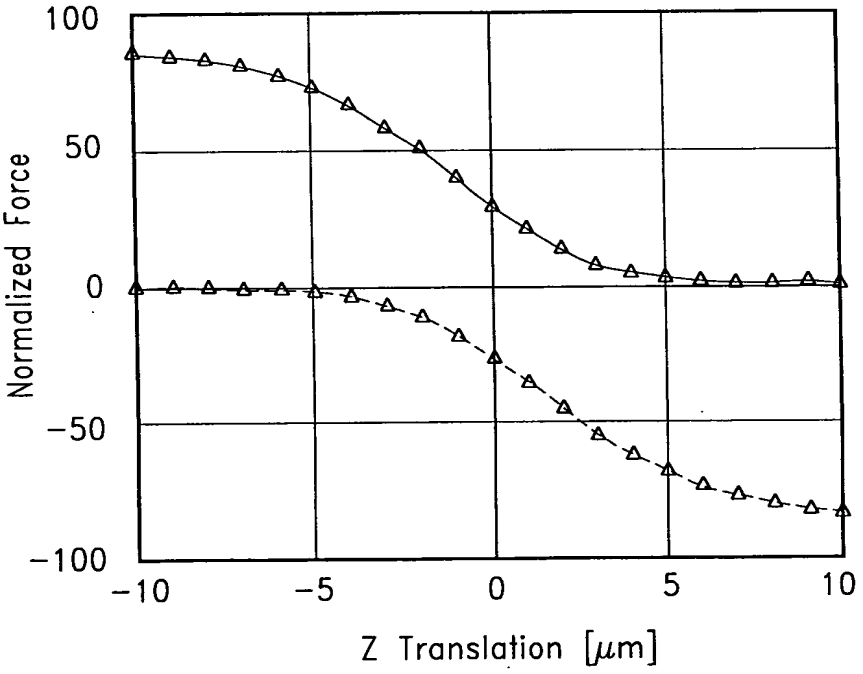

100
50
0
−50
−100
Normalized Force
−10
−5
0
5
10
Z Translation [μm]

FIG.23

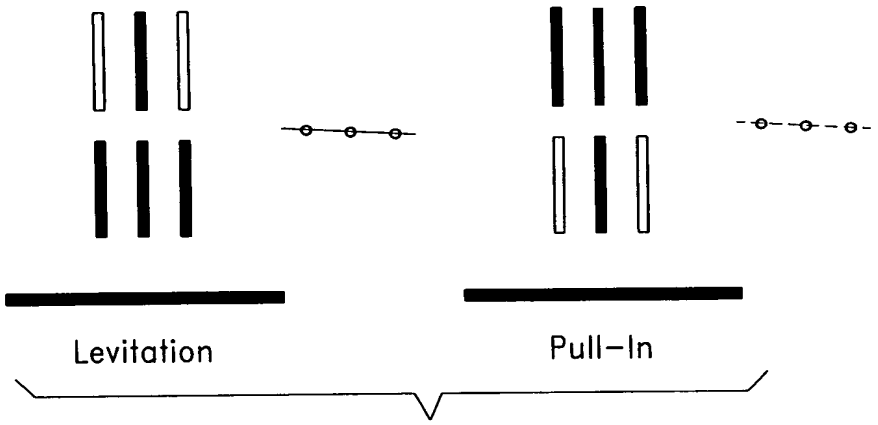

Levitation
Pull-In

FIG.24

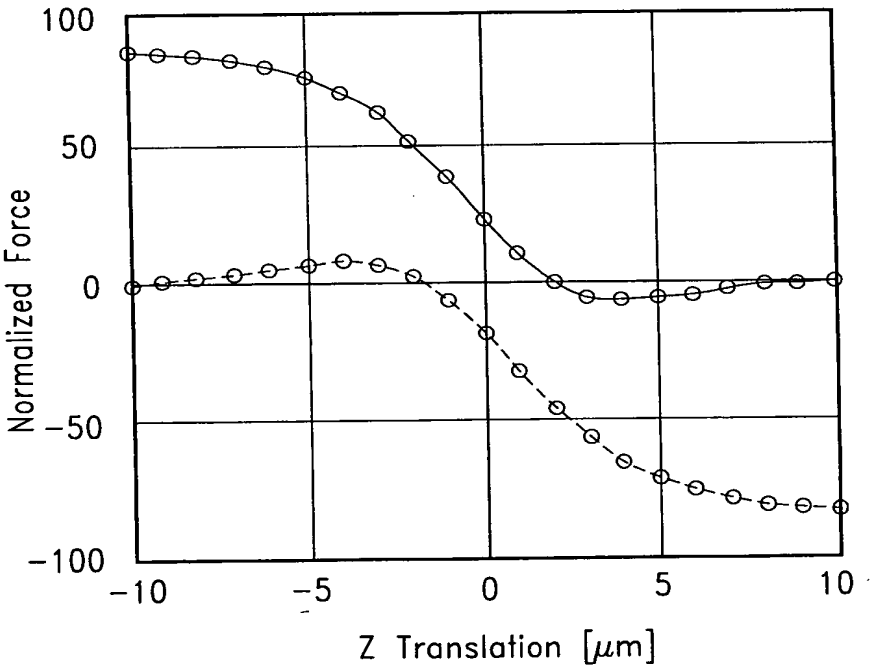
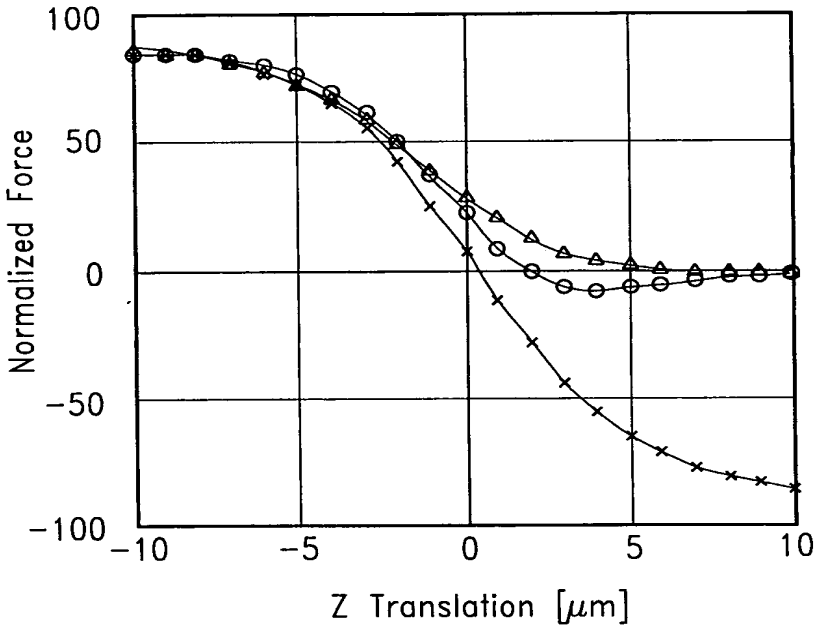
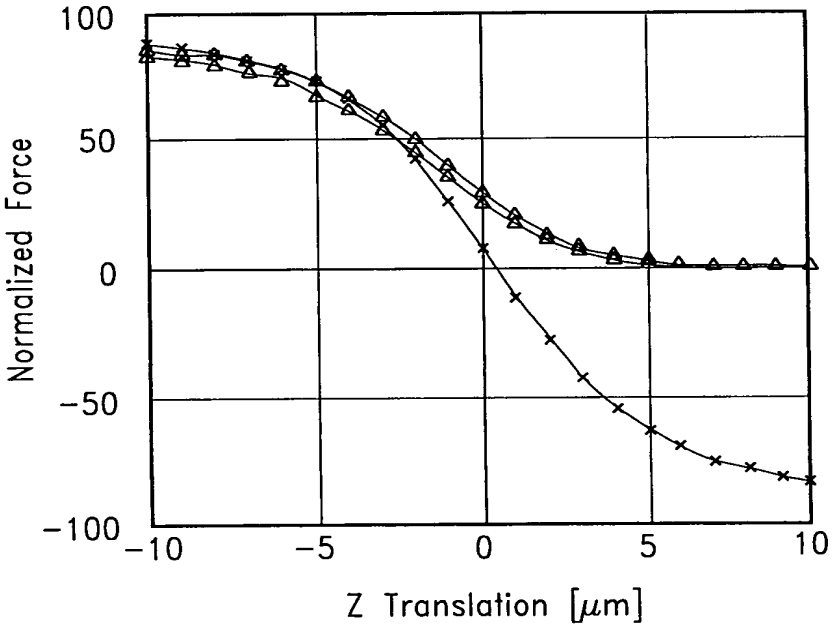

100
50
0
−50
−100
Normalized Force
−10
−5
0
5
10
Z Translation [μm]

FIG.25



Comparison of multiple−level actuator designs
Normalized force vs. displacement
for design (a) ○, design (b) △, and design (e) ×

FIG.26



Comparison of push − and pull − modes of a bi−directional actuator (design (b))

FIG.27

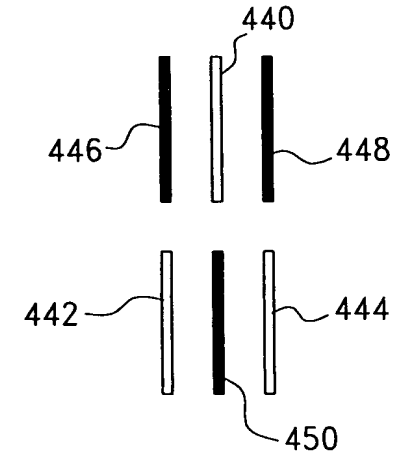


FIG.28(a)

Normalized force vs. displacement
for a two-level bistable system
-electrode bias conditions

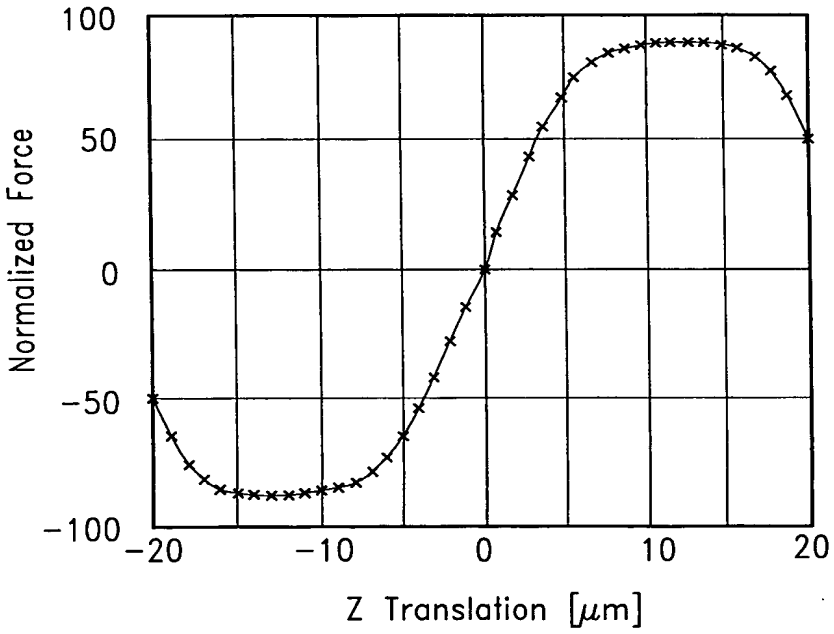
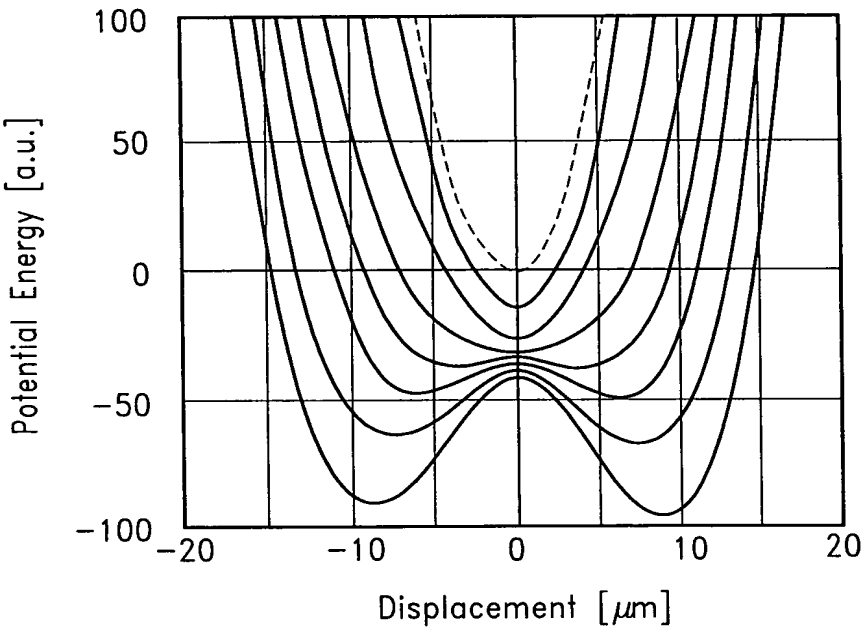


FIG.28(b)

Normalized force vs. displacement
for a two-level bistable system
-force vs. displacement



Potential energy vs. displacement
for the spring−actuator system
(the dotted line is for no−applied force)

FIG.29

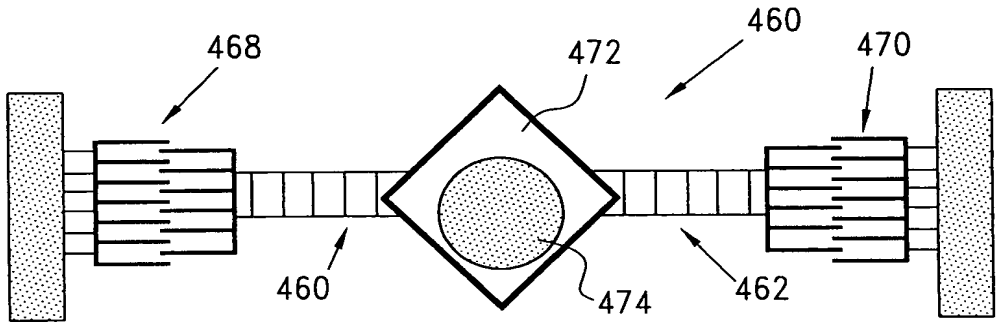


FIG.30(a)

Multiple-level Clamp-Alignment concept
for the spring-actuator system
-self-aligned initial position - no displacement of levels

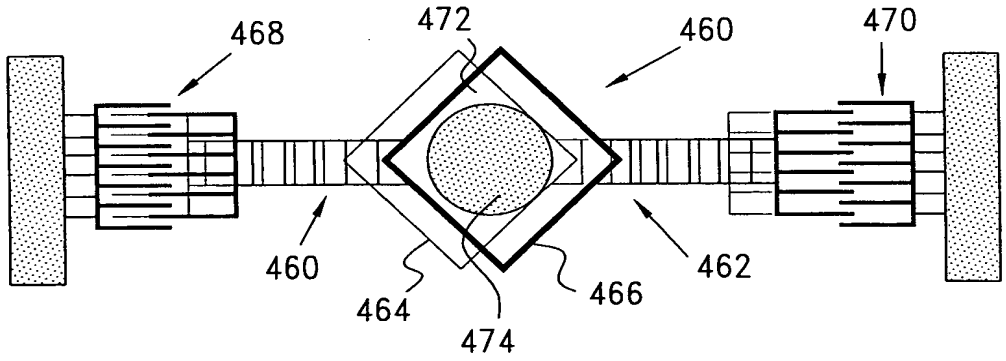


FIG.30(b)

Multiple-level Clamp-Alignment concept
for the spring-actuator system
-relative displacement and alignment of fiber

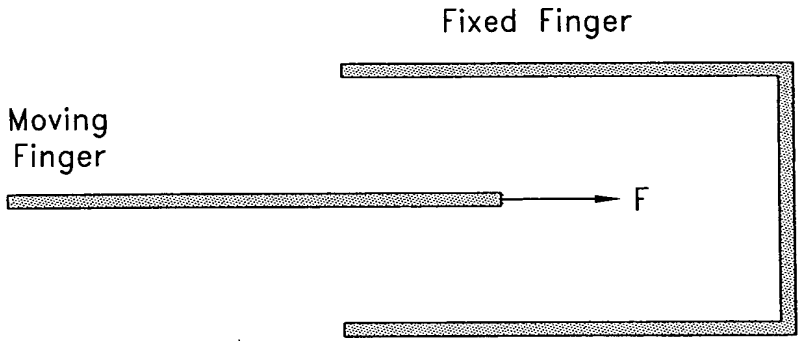


FIG.31(a)

Lateral instability in comb-drive actuators
-moving finger aligned at center - $F_L=0$

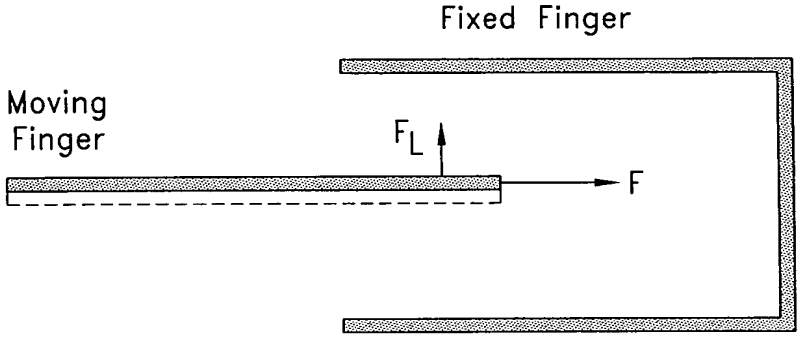


FIG.31(b)

Lateral instability in comb-drive actuators
-moving finger off center